

# Energy-Efficient High-Power IGBTs



(From 600V to 4500V)

IXYS Corporation (NASDAQ: IXYS) offers the broadest IGBTs product portfolios in the power semiconductor industry; designers can choose from the largest selection of devices – be they 600V, 650V, 1200V, or other higher voltage rated IGBTs. Through the combination of its eXtreme-light Punch-Through (XPT™) technology and advanced IGBT process, IXYS is able to achieve low energy losses and exceptional device ruggedness while still maintaining low on-state voltages.

## Extreme-Light Punch-Through (XPT™) Technology

As illustrated in Figure 1, the XPT™ is IXYS' proprietary thin-wafer technology behind most of the recently released IGBT product lines. These optimized IGBTs feature low thermal resistance, low total energy losses, high current densities, and a positive temperature coefficient of the on-state voltage. Figure 2 demonstrates an example of a superior switching performance of XPT™ devices across frequencies, compared to traditional Trench ones.

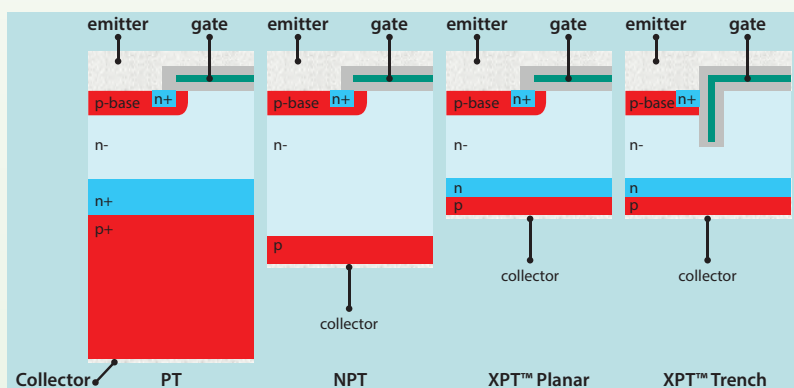


Figure 1: IXYS XPT™ IGBT technologies

IXYS also possesses an advanced 4<sup>th</sup> generation Trench IGBT process. By merging its two technologies, XPT™ and Trench IGBT process, IXYS is able to come up with XPT™ Trench IGBTs. These highly efficient low on-state voltage IGBTs are exceptionally rugged and exhibit low turn-off energy losses, which can be seen in Figure 3.

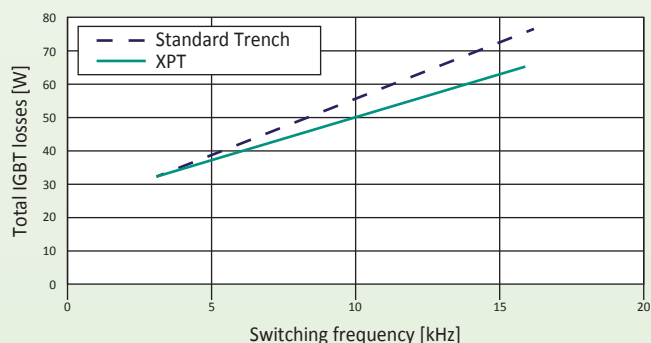


Figure 2: Total energy loss vs. frequency

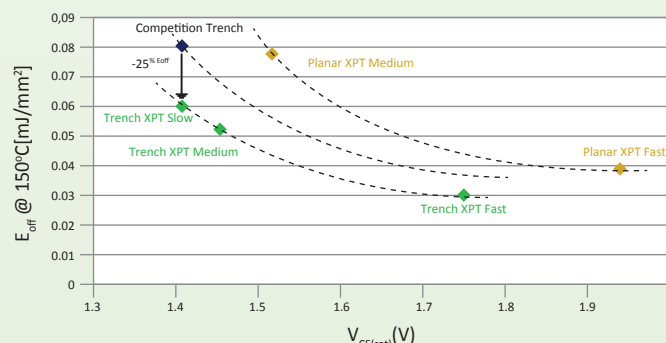


Figure 3: Trade-off performance [ $E_{off}$  vs.  $V_{CE(sat)}$ ]

### XPT™ Technology Advantages

- Thin wafer technology
- Reduced thermal resistance
- Low energy losses
- Fast switching
- Low tail current
- High current densities
- Positive temperature coefficient of  $V_{CE(sat)}$

# 600V XPT™ IGBTs

*Rugged. Efficient. Reliable.*

Developed using the IXYS XPT™ thin wafer technology and advanced 3<sup>rd</sup> generation (GenX3™) IGBT process, these devices feature excellent electrical characteristics which include low on-state voltages ( $V_{CE(sat)}$  as low as 1.6V), low current fall times ( $t_{fi}$  as low as 32ns), and low turn-off energy losses ( $E_{off}$  as low as 0.27mJ at  $T_J = 25^\circ\text{C}$ ). As their on-state voltage has a positive temperature coefficient, they can be used in parallel to meet high current specifications. Furthermore, their low gate charges help minimize gate drive requirements and switching losses.

## Best-In-Class Reliability: RBSOA, FBSOA, and SCSOA

These IGBTs exhibit exceptional ruggedness during switching and under short circuit conditions, establishing a new benchmark in device ruggedness. This is achieved through square Reverse Bias Safe Operating Areas (RBSOA) rated up to the blocking voltage, 10μs Short Circuit Safe Operating Areas (SCSOA), and dynamic avalanche ratings. Furthermore they have extended Forward Bias Safe Operating Areas (FBSOA), allowing for “wider operating windows” and resulting in improved ruggedness and reliability.

## Ultra-Fast Soft-Recovery Diodes (Sonic-FRD™ or HiPerFRED™)

The 600V XPT™ devices are available with Sonic-FRD™ or HiPerFRED™ anti-parallel ultra-fast diodes. The combination of the XPT™ IGBTs and these diodes results in optimal solutions in reducing turn-off losses. These IGBTs can withstand very high rates of change in current ( $di/dt$ ) thanks to the diodes’ soft recovery nature. The short reverse recovery times ( $t_{rr}$ ) and low reverse recovery currents of these diodes also help minimize turn-on energy losses ( $E_{on}$ ). In addition the Sonic-FRD™ diodes can be used in parallel operation due to the temperature stability of their forward voltage ( $V_F$ ), further minimizing switching losses.

### Key Features

- Optimized for high-speed switching (up to 60kHz)
- Extended Forward Bias Safe Operating Area (FBSOA)
- Short circuit capability (10μs)
- Square Reverse Bias Safe Operating Area (RBSOA)
- Internal standard packages

### Applications

- Battery chargers
- E-Bikes
- Motor drives
- Power inverters
- Welding machines

## Partial Parts list (30A-300A at $T_c = 110^\circ\text{C}$ )

Part Number	$V_{CES}$ (V)	$I_{C25}$ $T_c = 25^\circ\text{C}$ (A)	$I_{C110}$ $T_c = 110^\circ\text{C}$ (A)	$V_{CE(sat)}$ max $T_J = 25^\circ\text{C}$ (V)	$t_{fi}$ typ $T_J = 150^\circ\text{C}$ (ns)	$E_{off}$ typ $T_J = 150^\circ\text{C}$ (mJ)	$R_{thJC}$ max IGBT ( $^\circ\text{C}/\text{W}$ )	Configuration	Package Style
IXXH30N60C3D1	600	60	30	2.2	78	0.4	0.55	Copack (FRD)	TO-247
IXXH50N60C3	600	100	50	2.3	90	0.48	0.25	Single	TO-247
IXXH50N60B3D1	600	120	50	1.8	190	1.2	0.25	Copack (FRD)	TO-247
IXXR100N60B3H1	600	145	68	1.8	200	2.8	0.31	Copack (FRD)	ISOPLUS247™
IXXH75N60B3	600	160	75	1.85	170	2.2	0.2	Single	TO-247
IXXN200N60B3	600	280	160	1.7	215	3.45	0.16	Single	SOT-227B
IXXK200N60C3	600	340	200	2.1	90	2.1	0.092	Single	TO-264
IXXK300N60B3	600	550	300	1.6	200	3.7	0.065	Single	TO-264

## Available Packages



# 650V XPT™ Trench IGBTs

Highly Efficient Low On-State Voltage IGBTs for Hard or Soft Switching Applications

These new 650V XPT™ Trench IGBTs are designed to optimize the trade-off between “switching and conduction losses” and “on-state voltage.” The task is accomplished by using the IXYS eXtreme-light Punch Through (XPT™) technology and state-of-the-art 4<sup>th</sup> generation (GenX4™) Trench IGBT process. These devices consequently exhibit low turn-off energy losses [ $E_{off}$ ] while maintaining low on-state voltages [ $V_{CE(sat)}$ ].

Thanks to the underlying XPT™ thin-wafer technology, the IGBTs also feature reduced thermal resistance ( $R_{thJC}$ ), fast switching, low tail current, and high current densities. In addition, these IGBTs have a positive collector-to-emitter voltage temperature coefficient, making it possible for designers to use multiple devices in parallel to meet high current requirements.

## Exceptional Ruggedness: RBSOA and SCSOA

These devices have square Reverse Bias Safe Operating Areas (RBSOA) up to the breakdown voltage of 650V and twice the nominal currents at high temperatures – a necessary ruggedness in snubberless hard-switching applications. They are also short circuit rated (10 $\mu$ s Short Circuit Safe Operating Area (SCSOA) at a high temperature of 150°C), making them ideal for motor drive applications.

## Ultra-Fast Anti-Parallel Sonic-FRD™ Diode

The forward voltage ( $V_f$ ) of the Sonic-FRD™ diode has low sensitivity to temperature, enabling the diodes to be operated in parallel and minimizing switching losses at the same time. The co-packed anti-parallel Sonic-FRD™ diode is optimized to reduce turn-off losses and suppress ringing oscillations, thereby producing smooth switching waveforms and significantly lowering electromagnetic interference (EMI) in the process.

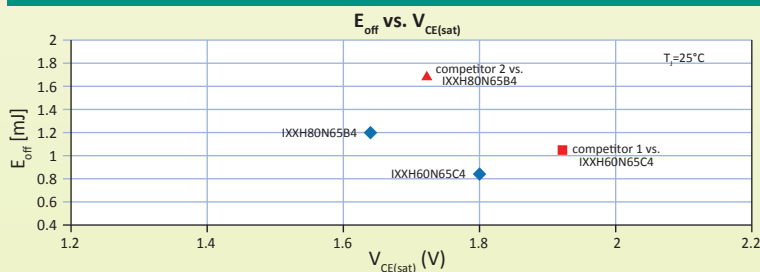
### Key Features

- Low on-state voltages  $V_{CE(sat)}$
- Optimized for high-speed switching (up to 60kHz)
- Short circuit capability (10 $\mu$ s)
- Square RBSOA
- Temperature stability of diode forward voltage  $V_f$

### Applications

- Battery chargers
- Lamp ballasts
- Motor drives
- Power inverters
- Welding machines

## Superior Trade-off: turn-off energy vs. on-state voltage

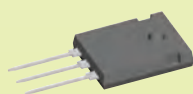


These 650V XPT™ Trench IGBTs are optimized to achieve low switching and conduction losses while maintaining low on-state voltages. The graph demonstrates a superior trade-off (turn-off energy loss vs. on-state voltage) of the new IGBTs (in particular, the IXXH60N65C4 against competitor 1 and IXXH80N65B4 against competitor 2)

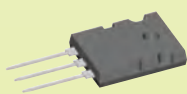
## Partial Parts list (30A-200A at $T_c=110^\circ\text{C}$ )

Part Number	$V_{CES}$ (V)	$I_{C25}$ $T_c=25^\circ\text{C}$ (A)	$I_{C110}$ $T_c=110^\circ\text{C}$ (A)	$V_{CE(sat)}$ max $T_j=25^\circ\text{C}$ (V)	$t_{fi}$ typ $T_j=150^\circ\text{C}$ (ns)	$E_{off}$ typ $T_j=150^\circ\text{C}$ (mJ)	$R_{thJC}$ max IGBT ( $^\circ\text{C}/\text{W}$ )	Configuration	Package Style
IXXH30N65B4	650	65	30	2	100	0.6	0.65	Single	TO-247
IXXH60N65B4H1	650	116	60	2	94	1.34	0.33	Copacked (Sonic-FRD™)	TO-247
IXXH40N65B4	650	120	40	1.8	73	0.78	0.33	Single	TO-247
IXXN110N65C4H1	650	210	110	2.35	43	0.77	0.2	Copacked (SONIC-FRD™)	SOT-227B
IXXX160N65C4	650	290	160	2.1	57	1.3	0.16	Single	PLUS247
IXXK200N65B4	650	370	200	1.7	110	2.54	0.13	Single	TO-264

## Available Packages



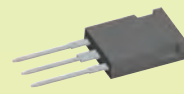
TO-247



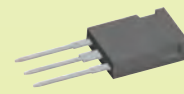
TO-264



SOT-227B



PLUS247



ISOPLUS247™

# 1200V XPT™ IGBTs

Optimized For High-Speed Hard-Switching Applications

Manufactured through the state-of-the-art GenX3™ IGBT process and an eXtreme-light Punch-Through (XPT™) design platform, the 1200V IGBTs display such qualities as high-current handling capabilities, high-speed switching abilities, low total energy losses, and low current fall times. The XPT™ thin wafer technology also helps reduce thermal resistance ( $R_{thJC}$ ) and on-state voltage ( $V_{CE(sat)}$ ), resulting in higher current densities, reduced chip sizes, and improved packaging capabilities.

Designers can operate these devices in parallel to satisfy high current requirements, taking advantage of the positive temperature coefficient of the on-state voltage of the IGBTs. Having low gate charges, the devices also help lower gate driver requirements and switching losses.

## Square Reverse Bias Safe Operating Areas (RBSOA)

These IGBTs are avalanche rated, and their square RBSOAs go up to the breakdown voltage of 1200V at high temperatures, displaying the ruggedness needed in snubberless hard-switching applications.

## Ultra-Fast Anti-Parallel Recovery Diodes (Sonic-FRD™ or HiPerFRED™)

The new 1200V XPT™ devices are also available with co-packed anti-parallel Sonic-FRD™ or HiPerFRED™ diodes. Optimized to reduce turn-off losses and suppress ringing oscillations, the diodes help produce smooth switching waveforms and significantly lower electromagnetic interference (EMI) in the system. Due to the soft recovery characteristics of the diodes, the IGBTs can be switched on at very high rates of change in current ( $di/dt$ ), even in low current and temperature conditions where diode snappiness can often occur. The diodes exhibit low reverse recovery currents along with short reverse recovery times ( $t_{rr}$ ), effectively minimizing the turn-on energies ( $E_{on}$ ) of the IGBTs. The Sonic-FRD™ diodes can be operated in parallel as their forward voltage ( $V_f$ ) has low sensitivity to temperature.

### Key Features

- Optimized for high-speed switching (up to 60kHz)
- Square RBSOA
- Positive thermal coefficient of  $V_{CE(sat)}$
- Avalanche rated
- Low gate drive requirements

### Applications

- Power inverters
- Uninterruptible Power Supplies (UPS)
- Power Factor Correction (PFC) circuits
- Battery chargers
- Switch-mode power supplies

## Partial Parts list (9A-120A at $T_c=110^\circ\text{C}$ )

Part Number	$V_{CES}$ (V)	$I_{C25}$ $T_c=25^\circ\text{C}$ (A)	$I_{C110}$ $T_c=110^\circ\text{C}$ (A)	$V_{CE(sat)}$ max $T_j=25^\circ\text{C}$ (V)	$t_{fi}$ typ $T_j=150^\circ\text{C}$ (ns)	$E_{off}$ typ $T_j=150^\circ\text{C}$ (mJ)	$R_{thJC}$ max IGBT ( $^\circ\text{C}/\text{W}$ )	Configuration	Package Style
IXYJ20N120C3D1	1200	16	7	4	105	0.7	1.78	Copacked (FRED)	ISO TO-247
IXYH20N120C3D1	1200	36	17	4	105	0.7	0.54	Copacked (FRED)	TO-247
IXYP20N120C3	1200	40	20	4	105	0.7	0.54	Single	TO-220
IXYN100N120B3H1	1200	165	76	2.6	260	10.1	0.18	Copacked (FRED)	SOT-227B
IXYK120N120C3	1200	220	120	3.5	120	5.3	0.1	Single	TO-264
IXYX100N120B3	1200	225	100	2.6	260	10.1	0.13	Single	PLUS247

## Available Packages





# SimBus F...flexible solutions for 2- and 3- level topologies

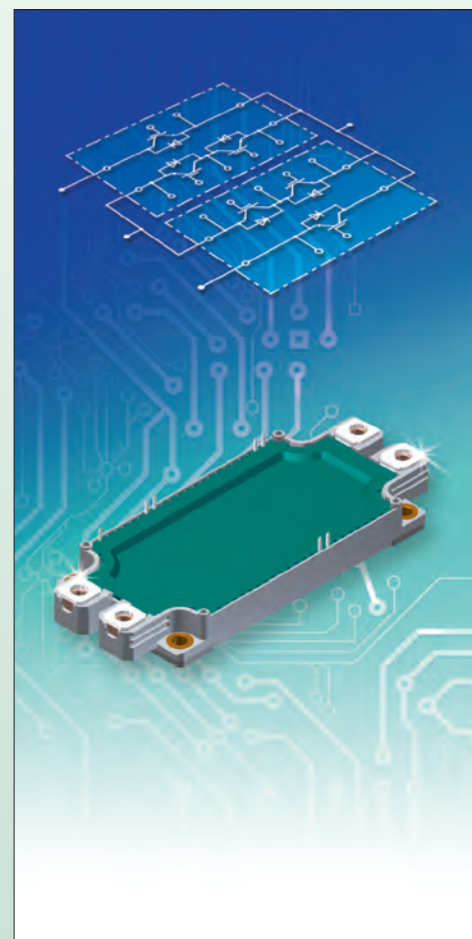
## New 17 mm Module Generation

**SimBus F** represents one of the newest package developments of IXYS. This new generation of DCB-isolated copper base modules provide several new features. Combined with the benefits of well-proven technologies **SimBus F** is an optimized semiconductor product for power conversion with focus on 2-level and 3-level inverter applications. The outline of this package type using the industrial standard height of 17 mm facilitating easy bus bar connections between the rectifier and inverter stages. Direct Copper Bonded (DCB) substrates – also manufactured at IXYS – allow the user 4800 V isolation voltage between terminals and heat sink.

**SimBus F** is a standard module housing optimized for IGBT phase leg configuration featuring high current density and low stray inductance. Equipped with IXYS XPT IGBTs and SONIC free wheeling diodes **SimBus F** gives the customer a reliable solution which is 100% sourced by IXYS. Common applications for the SimBus F are solar inverters, motor drives, DC to DC chopper systems and UPS power inverters.

The first modules released are the 450A, 300A and 225A dual IGBT and the 225A brake/boost modules equipped with 1200V IXYS XPT IGBTs. The voltage range is extended to 650 V by the dual XPT IGBT 600 A MIXA600PF650TSF and further expanded by the MIXA600AF650TSF (common emitter) and MIXA600CF650TSF (common collector) options.

MIXA430LD1200TSF is one half of a 3-level T-type (or NPC2 type) inverter topology using a combination of 650V and 1200V XPT IGBTs. Two of these modules in anti-parallel can form a simple solution for a T-type multi-level inverter featuring a reinforced switch to DC- neutral. With 1700V IGBTs and the combination of 1200V/1700V IGBTs, multi-level solutions will be available.



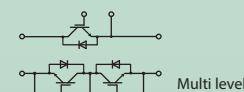
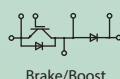
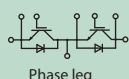
### Features

- Easy paralleling
- Rugged XPT design (Xtreme light Punch Through)
  - short circuit rated for 10  $\mu$ sec.
  - very low gate charge
  - square RBSOA @ 2 x Ic
- SONIC™ diode
  - fast and soft reverse recovery
  - low operating forward voltage
- NTC included

### Applications

- AC motor control
- Solar inverter
- Soft starts
- UPS inverter
- Welding equipment
- Induction heating
- Pumps or fan controls

Products	Vce / V	Ic80 / A	Circuit
MIXA225PF1200TSF	1200	250	Phase leg
MIXA300PF1200TSF	1200	325	
MIXA450PF1200TSF	1200	450	
MIXA600PF650TSF	650	490	
MIXA225RF1200TSF	1200	250	Brake / Boost
MIXA600AF650TSF	650	490	Common emitter
MIXA600CF650TSF	650	490	Common collector
MIXA430LD1200TSF	1200/650	430/345	Multi Level (one half)



# 2500V and 4500V Press Pack IGBTs

As a leading innovator in press-pack IGBT technology IXYS UK offers the widest product portfolio bar none. These highly robust devices have been established in the market for more than 10 years; however, IXYS UK continues to develop and improve on the products available. The current portfolio offers devices with 2.5kV and 4.5kV blocking voltages and current ratings from 160A to 2400A. A representative range of available devices is tabulated below, including both asymmetric and reverse blocking types.

The advanced die technology is based on an enhanced planar cell design featuring the latest carrier enhancement techniques. Delivering comparable  $V_{CE(sat)}$  to modern trench designs while retaining the superior RBSOA performance and easy driving characteristics of traditional planar technology.

The construction of these devices is completely free from wire and solder bonds, which all but eliminates the problems of mechanical fatigue associated with conventional modules. Internal stray inductance in both the gate connections and emitter connections is vastly reduced when compared to conventional modules leading to improved ruggedness and short circuit behavior, which is further enhanced by the direct cooling of the emitter side of the die.

Each die is mounted in its own individual cell (Fig 1) which is then collectively mounted in the fully hermetic package (Fig 2, 3). Contact is made through applying pressure to the external copper electrodes. A typical three level phase leg using 125mm electrode T2400GB45E devices is illustrated in Fig 4. The illustrated stack demonstrates how the devices offer a compact solution for very high powers, especially in medium voltage applications where more than one device needs to be connected in series. Devices can be mounted directly in line with each other between the coolers without the need for complex bus bar arrangements. The inherent failure to s/c of the device also allows the option for n+1 redundancy – a feature which makes the device very suited to medium voltage drives, HVDC and active Var controllers.

The internal cell structure gives exceptional power cycling performance, typically an order of magnitude greater than a module, making them highly suitable for applications like transportation and induction melting with extreme power cycling requirements. The package has a high rupture rating which fits well to safety critical applications in mining, marine, and petro-chemical industries. Also as the package is fully hermetic it is suited to all cooling options, including direct liquid immersion.

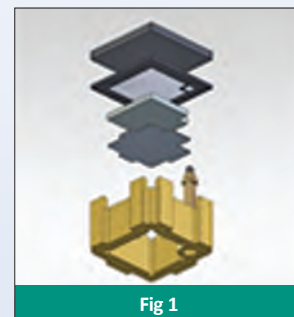


Fig 1



Fig 2



Fig 3

Type part No.	$V_{CES}$ V	$I_C$ A	Reverse conducting
T0340VB45G	4500	340	Yes
T0530VB45E	4500	530	No
T0570VB25G	2500	570	Yes
T0800EB45G	4500	800	Yes
T0850VB25E	2500	850	No
T1200EB45E	4500	1200	No
T1500TB25E	2500	1500	No
T1600GB45G	4500	1600	Yes
T2250AB25E	2500	2250	No
T2400GB45E	4500	2400	No

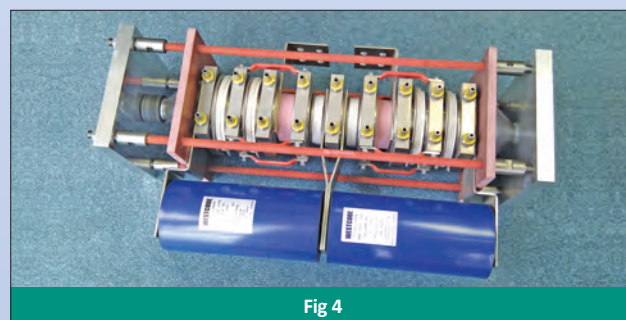


Fig 4